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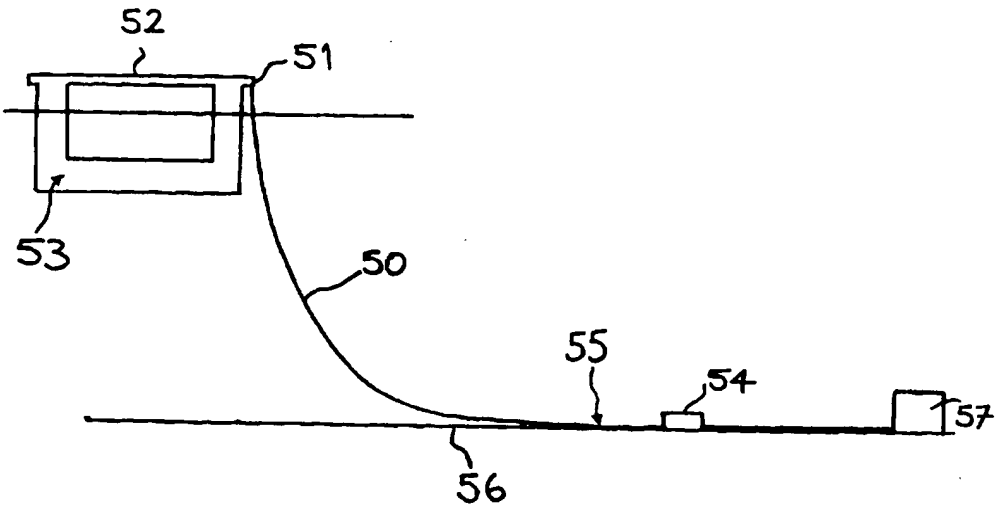

(57) Abstract

Conventional riser assemblies for conveying fluids from undersea oil or gas deposits use flexible hoses. Such hoses are prohibitively expensive for use in deep water locations and are prone to failure. The invention provides an offshore oil or gas production system comprising a floating production vessel (53) and a riser assembly (50) extending between the vessel and a seabed well head (57). The riser assembly comprises at least one flexible steel riser (50) suspended, in catenary, from an outer edge (51) of a deck (52) of the floating production vessel and an anchor (54) located on the seabed (56) and spaced from the well head (57). A riser assembly comprising a plurality of flexible steel risers can be installed quickly by simultaneously laying a plurality of such risers from a reel mounted on a pipe laying vessel and simultaneously disconnected and lowered into a trench on the seabed if it becomes necessary to move the vessel.

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RISER ASSEMBLY

This invention relates to a riser assembly suitable for conveying fluids, for example oil, gas, or water, or a mixture of these fluids, from an offshore deposit or reservoir to a floating production vessel.

In a conventional oil production system, for the production of well fluids from an undersea hydrocarbon deposit, a flexible hose may form a riser which is suspended from a floating oil production vessel, for example a semi-submersible or other vessel. The riser is connected via a valve arrangement to a well head. This conventional riser or hose comprises a flexible but intricate structure of counterwound layers of material. An example of these types of hose are described in FR 2370219 (Coflexip). These hoses are not able to withstand well pressure directly and must be connected to the well head via subsea chokes which limit fluid pressure. Furthermore, due to their intricate design, they are very expensive and make up a significant amount of the total cost of an offshore production platform. Consequently, operators have attempted to reduce costs by linking together several well heads on the seabed via a manifold system which must also include check valves to prevent cross circulation between wells. This increases the complexity and quantity of equipment installed on the seabed and consequently increases installation and

maintenance costs. A further problem is that these types of flexible risers are prone to failure from blowouts, twisting, buckling and separation of the layers. They have a relatively short operating life.

As present oil or gas reserves become depleted, the desire to find alternative sources or deposits becomes stronger. This has inevitably led to the exploitation of oil and gas deposits in more remote and inaccessible locations. Producing oil or gas is much less profitable as equipment tends to be more expensive as a result of having to operate in more difficult conditions. Furthermore, in deep water locations the cost of installing and maintaining equipment located on the seabed rises drastically, as does the cost of using flexible risers. Also flexible risers, of the Coflexip design, are likely to have a shorter operating life in these environments.

The riser assembly of the invention addresses the problems and disadvantages associated with conventional flexible riser systems and provides an improved riser assembly which is cheaper to install and easier to maintain.

According to one aspect of the invention there is provided an offshore oil or gas production system comprising a floating production vessel and a riser assembly extending between the vessel and a seabed well head, said riser assembly comprising at least one flexible steel riser suspended, in catenary, from an outer edge of a deck of said floating production

vessel and anchor means located on the seabed and spaced from the well head.

Preferably, the or each riser comprises a plurality of pipe means joined endwise to form a continuous steel riser.

The pipe means may comprise an inner pipe and an outer pipe, said outer pipe surrounding at least a portion of said inner pipe and defining an annular space therebetween.

The pipe means may comprise port means whereby the annular spaces of adjacent pipe means of a riser can be connected to allow fluid communication therebetween.

The or each riser may be assembled from a plurality of straight pipe means. This has the advantages that straight pipe means are relatively cheap to manufacture, and easy to store and transport. Furthermore, a damaged portion of such a riser can be replaced easily thereby making repairs more effective and cheaper.

The or each riser may have a curved configuration in an unstressed state thereof. To this end, the or each riser may be preformed i.e. be plastically deformed to produce a riser which adopts a curved configuration in its unstressed state. A pre-curved riser enables a steel riser to be used in shallower depths without exceeding the threshold radius of curvature which causes plastic deformation or flow.

Preferably, in use, a portion of the or each

riser remains in contact with the seabed substantially at all times.

Preferably, an upper end of the or each riser is supported in bearing means adapted to accommodate rotational or twisting movement of the riser.

Preferably, a plurality of said flexible steel risers are suspended from an outer edge of a deck of such a vessel, each said riser being arranged to service a single well. This eliminates the need to use complex manifold apparatus on the seabed (to enable one riser to service several wells), as is presently necessary with conventional riser assemblies. A problem with such manifold apparatus is that check valves have to be used to prevent cross circulation between wells and these are prone to failure. This problem is eliminated by providing one riser for each well.

Preferably, each said riser has substantially the same curvature between the production vessel and the seabed. In this way, the risers form a curtain of tubes or pipes. This helps to restrict twisting movement of the production vessel at the surface enhancing the mooring capability of the riser assembly. Also, it facilitates laying-down of the risers on the seabed. Furthermore, any individual riser can be removed or serviced easily and the arrangement of the control apparatus at the surface can be simplified.

Advantageously, the risers are secured to the

seabed by a common anchor means, said anchor means maintaining a predetermined separation of the risers.

Preferably, choke means and/or manifold means are connected with upper ends of the risers and secured to said deck of the production vessel. In this way, the valves and associated apparatus for controlling well fluids are located in the "dry" on the deck of a production vessel where they can be serviced and controlled easily. This brings offshore practice closer to that used onshore. The well can be inspected and serviced from the deck of a floating production vessel.

Crossover tube means may be provided between the risers at the seabed. This allows the risers to be pigged or cleaned regularly to prevent waxing up. The crossover tube means allows a pig to be pumped down one riser and returned to the surface up another riser, with wax being pushed in front of the pig and into a container on board the production vessel.

According to a second aspect of the invention there is provided an offshore oil or gas production system comprising a floating production vessel and a riser assembly extending between the vessel and seabed well heads, said riser assembly comprising a plurality of flexible steel risers suspended, in catenary, from the floating production vessel and anchor means located on the seabed, an end of each said riser being adapted to be connected with a respective well head; wherein the risers are arranged to be substantially

coplanar at the sea surface.

Preferably, said risers each have substantially the same curved configuration. The risers define a curtain of production tubes which descend, in catenary, to the seabed. Other tubes, necessary for the operation of the well, may be included in this curtain. These might include, for example, export riser means, water injection riser means and/or control umbilical means.

According to another aspect of the invention there is provided a method of installing a riser assembly for an offshore oil or gas production vessel which comprises:

laying a plurality of steel risers, simultaneously, from a reel mounted on a pipe laying vessel,

securing one end of each riser to a respective well head or to anchor means,

securing the other end of each riser to a deck of such an oil or gas production vessel, and

controlling the curvature of the risers, during installation, in order to avoid exceeding the elastic limit of the riser material.

The method has the advantage that more than one riser can be installed at the same time thereby reducing the time taken to install a riser assembly on an offshore oil or gas production vessel.

Preferably, the risers are installed to form a curtain of riser pipes or tubes which are

substantially coplanar at the surface.

A coplanar arrangement of riser pipes has the advantage that servicing and maintaining the risers is made easier, and that the arrangement enhances the stability of the vessel.

At least one of the risers may comprise pipe means comprising an inner and outer pipe arranged to define an annular flowpath therebetween. Advantageously, gas is injected into said annular flowpath to selectively vary the buoyancy of the riser.

According to a further aspect of the invention there is provided a method of disconnecting a riser assembly from an offshore oil or gas production vessel which comprises:

disconnecting the riser assembly from the deck of a vessel,

lowering the riser assembly, under tension, into an elongate trench formed in the seabed, and

controlling the tension throughout to ensure that the elastic limit of the riser material is not exceeded as the assembly is lowered.

In certain circumstances, for example to avoid adverse weather conditions or other environmental hazards, it is necessary for the gas or oil production vessel to move off station ie. to move away from its moored position. In order to do this all connections to the seabed including moorings, risers, control umbilicals etc., must be disconnected. With

conventional production vessels this task is extremely time consuming and difficult to the extent that it is not practical. This limits the range of environments in which the production vessel may operate. However, with the method recited in the last preceding paragraph it is possible to do this easily and simply. The trench protects the riser assembly while it is resting on the seabed for example from damage by icebergs, or the activities of trawlers.

Preferably, tension is maintained by the oil production vessel as it moves off station. The production vessel can maintain tension on the riser assembly, which might include a plurality of steel risers, by use of a cable.

Preferably, said risers are maintained in a substantially coplanar arrangement.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic of an oil or gas production vessel, riser assembly and seabed trench;

Figure 2 is a side view of a pipe for forming a riser;

Figure 3 is a side view of a pipe means for forming a riser with a portion of an outer pipe thereof cut away to show detail of an annular space surrounding an inner pipe;

Figure 4 is a side view of the pipe means shown in Figure 3 with the outer pipe removed to reveal a

geometric arrangement of spacers separating the inner and outer pipes;

Figure 5 is a schematic of an oil or gas production vessel and riser assembly, the riser assembly being suspended, in catenary, between an edge of the deck and the seabed; and

Figure 6 is a schematic showing one possible mooring arrangement for securing the oil or gas production vessel.

Referring to the drawings in detail, Figure 1, shows a floating oil or gas production vessel 1 moored to the seabed 2 via moorings 3. The moorings can be typical chain moorings well known to the skilled man in the art. The vessel 1 has four legs 4 which support a deck or platform (not shown) which houses equipment or apparatus for controlling the well. A plurality of steel risers 5 are secured to the edge of the deck of the production vessel at the surfaces. The steel risers 5 are substantially coplanar at the surface and are suspended, in catenary, between the edge of the deck and a common anchor 6. The risers 5 form a curtain of production pipes or tubes which curve down to the seabed with substantially the same curved configuration or catenary shape.

The steel risers can be sufficiently rigid to restrain movement of the vessel at the surface. This can mean that the system of moorings 3 is placed under less strain and in some circumstances it may be possible to moor the vessel solely using steel

catenary risers. A coplanar arrangement of risers has the advantage that twisting motion of the vessel at the surface is restrained. Vessel movement must be kept within predetermined limits, particularly, those movements which tend to increase the curvature of the risers thereby increasing the stress in the pipes which form the risers.

Chokes and manifolds are connected to the upper ends of the risers 5 on the deck of the vessel 1 at the surface. The valves and associated apparatus for controlling well fluids are located in the "dry" where they can be serviced and controlled easily. The upper ends of each of the risers 5 are supported in bearings to accommodate rotational or twisting movement. Other movement is accommodated by the elastic nature of the risers 5.

The steel risers 5 comprise lengths of steel pipe joined endwise to form a continuous steel riser. These lengths of pipe may be straight, the riser adopting its curved or catenary shape within the elastic limits of the steel. No plastic flow or deformation of the pipes occurs. However, in less deep water there may not be sufficient depth for the riser to be suspended in catenary without the curvature causing plastic flow and pipe kinking. Once a kink is formed it can rapidly propagate along a pipe due to external pressure of the water. In these circumstances pre-curved lengths of pipe can be used to overcome the problem.

The common anchor 6 secures the risers to the seabed and prevents loads being transferred to the well heads 7 by movement of the vessel at the surface, or tidal flow or currents. The common anchor 6 also maintains the spaced apart relationship of the risers 5. The ends of the risers 5 may also be secured to the respective conductor tubes of wells being serviced by the risers. A portion 8 of the risers always remains in contact with the seabed.

Figure 2 shows a length of steel pipe 20 which can be used to form a flexible steel riser 5. Lengths of such piping are joined endwise via flanges 21. Sizes of pipe 20 might range from 4 inches (approximately 101.6 mm) to 12 inches (approximately 304.8 mm) in diameter.

Figure 3 shows a pipe means 30 which can be used as an alternative to the pipe 20. The riser is formed by joining identical lengths of the pipe means 30 in end to end relation via flanges 31. The pipe means 30 comprises an inner pipe 32 and an outer pipe 33 which surrounds the inner pipe 32 terminating at either end adjacent the flanges 31. The inner and outer pipes define an annular space 34 therebetween. Radial spacers 35 increase the rigidity and strength of the pipe means 30 and ensure that the inner and outer pipes are kept spaced apart.

The pipe means 30 comprises ports 36, 37 at the respective ends thereof which can be connected to the ports of adjacent pipes connecting the respective

annular spaces 34 to provide a continuous annular flowpath from the well head to the surface. The annular flowpath can be used to produce fluid from the annulus of a well, or to inject fluids into the annulus. The annular flowpath can be injected with a gas to increase the buoyancy of the riser 5 and thereby reduce stress at the surface caused by the weight of the riser; preferably the gas would be air. This can be important in deep water locations where the weight of the steel riser may place the riser under considerable stress. The annular space 34 can also serve as a shield or protective jacket to protect the environment from leakages in the event of a blowout or failure.

The pipe 20, 30 may be lined with a protective coating, for example 3 mm thick Inconel, so that corrosive fluids can be handled.

Figure 4 shows an alternative pipe means 30' with the outer pipe removed to show an alternative geometric arrangement of radial spacers 35'.

Figure 5 shows a steel riser 50 suspended, in catenary, between the edge 51 of a deck 52 of a semi-submersible oil or gas production vessel 53 and an anchor 54. In use, a portion 55 of the riser 50 always remains in contact with the seabed 56. The riser is connected to a well head 57.

Figure 6 illustrates one configuration of mooring lines 60 for restraining movement of an oil or gas production vessel 61 at the surface.

It will be appreciated that the use of flexible steel risers in preference to flexible risers of the type described in FR 2370219 and supplied by Coflexip, or by the US Company Wellstream, is particularly advantageous in deep water where the use of conventional flexible risers becomes prohibitively expensive. The radius of curvature of the riser is carefully controlled and maintained so that plastic deformation or flow is not induced. This ensures that any stress caused by, for example movement of the production platform, internal fluid pressure, or external fluid pressure, is within the elastic regime of the material of the riser. As steel risers can withstand direct well pressure, the need to use complex and difficult-to-maintain subsea chokes and manifolds is eliminated. Instead this equipment can be located at the surface on the deck of the production vessel where it is easier to control and maintain. This brings offshore practice closer to that used onshore. Furthermore, the stiffness of flexible steel risers can be used to help restrain movement of the floating vessel within set limits, thereby allowing the extent of the mooring system to be reduced. Fewer chains can be used to anchor the vessel or, if existing mooring systems are used, the safety margin is increased.

Referring again to Figure 1, in certain circumstances it is desirable or necessary to move the production vessel 1 off station. In order to do this

the risers 5 are disconnected at their upper ends from the valves and chokes on the deck. The ends are then lowered on a cable into the water as the vessel 1 moves off station in the direction indicated by the arrow 9. Movement of the vessel can be achieved by it pulling away on its moorings or by use of its own propulsion. Tension is maintained to ensure that the curvature of the risers 5 is kept within the elastic regime of the steel pipes of which they are formed. The curtain of risers 5 is lowered into a trench 10 located on the seabed which serves to protect the riser assembly when not in use.

CLAIMS:

1. An offshore oil or gas production system comprising a floating production vessel and a riser assembly extending between the vessel and a seabed well head, said riser assembly comprising at least one flexible steel riser suspended, in catenary, from an outer edge of a deck of said floating production vessel and anchor means located on the seabed and spaced from the well head.

2. A system as claimed in claim 1, wherein the or each riser comprises a plurality of pipe means joined endwise to form a continuous steel riser.

3. A system as claimed in claim 2, wherein said pipe means comprises an inner pipe and an outer pipe, said outer pipe surrounding at least a portion of said inner pipe and defining an annular space therebetween.

4. A system as claimed in claim 3, wherein said pipe means comprises port means whereby the annular spaces of adjacent pipe means of a riser can be connected to allow fluid communication therebetween.

5. A system as claimed in claim 2, 3 or 4, wherein

the or each riser is assembled from a plurality of straight pipe means.

6. A system as claimed in any one of the preceding claims, wherein the or each riser has a curved configuration in an unstressed state thereof.

7. A system as claimed in any one of the preceding claims wherein, in use, a portion of the or each riser remains in contact with the seabed substantially at all times.

8. A system as claimed in any one of the preceding claims, wherein an upper end of the or each riser is supported in bearing means adapted to accommodate rotational or twisting movement of the or each riser.

9. A system as claimed in any one of the preceding claims, comprising a plurality of said flexible steel risers suspended from an outer edge of a deck of such a vessel, each of said risers being arranged to service a single well.

10. A system as claimed in claim 9, wherein each said riser has substantially the same curvature between the production vessel and the seabed.

11. A system as claimed in claim 9 or 10, wherein said risers are secured to the seabed by a common anchor means, said anchor means maintaining a predetermined separation of the risers.

12. A system as claimed in claim 11, wherein each riser is further anchored to a conductor tube of the respective well being serviced by the riser.

13. A system as claimed in any one of claims 9 to 12, wherein choke means and/or manifold means are connected with upper ends of the risers and secured to said deck of the production vessel.

14. A system as claimed in any one of claims 9 to 13, wherein crossover tube means is provided between the risers at the seabed.

15. An offshore oil or gas production system comprising a floating production vessel and a riser assembly extending between the vessel and seabed well heads, said riser assembly comprising a plurality of flexible steel risers suspended, in catenary, from the floating production vessel and anchor means located on the seabed, an end of each said riser being adapted to be connected with a respective well head; wherein the

risers are arranged to be substantially coplanar at the sea surface.

16. A system as claimed in claim 15, wherein said risers each have substantially the same curved configuration.

17. A system as claimed in claim 15 or 16, wherein said plurality of risers partially defines a curtain of production tubes which descend from said vessel, in catenary, to the seabed, said curtain further comprising export riser means, water injection riser means and/or control umbilical means.

18. A method of installing a riser assembly for an offshore oil or gas production vessel, the method comprising:

laying a plurality of steel risers, simultaneously, from a reel mounted on a pipe laying vessel,

securing one end of each riser to a respective well head or to anchor means,

securing the other end of each riser to a deck of such an oil or gas production vessel, and

controlling the curvature of the risers, during installation, in order to avoid exceeding the elastic

limit of the riser material.

19. A method as claimed in claim 18, wherein the risers are installed to form a curtain of riser tubes which are substantially coplanar at the surface.

20. A method as claimed in claim 18 or 19, wherein at least one said riser comprises pipe means comprising an inner pipe and an outer pipe arranged to define an annular flowpath therebetween, comprising the step of injecting gas into said annular flowpath to selectively vary the buoyancy of the riser.

21. A method of disconnecting a riser assembly from an offshore oil or gas production vessel, the method comprising:

disconnecting the riser assembly from the deck of a vessel, lowering the riser assembly, under tension, into an elongate trench formed in the seabed, and

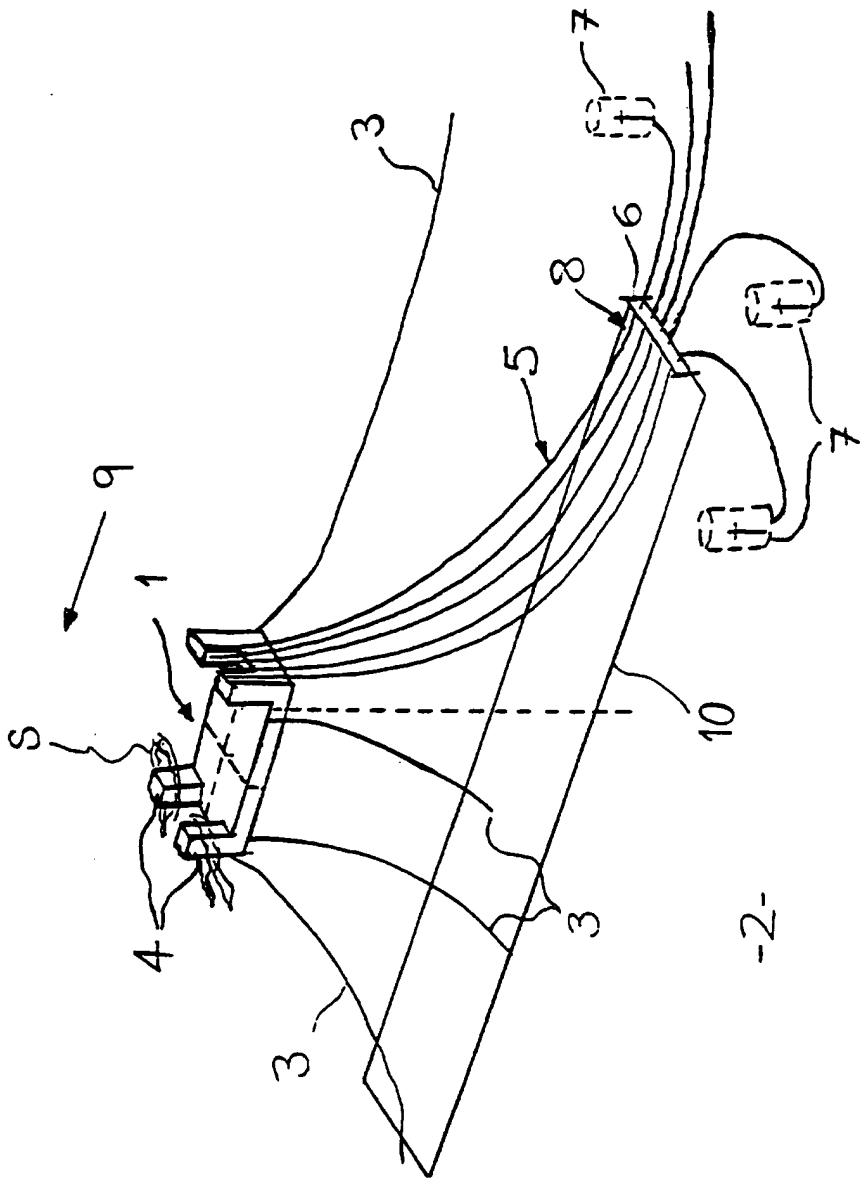
controlling the tension on said riser assembly to ensure that the elastic limit of the riser material is not exceeded as the assembly is lowered.

22. A method as claimed in claim 21, comprising moving said vessel off station and maintaining said tension by said vessel.

23. A method as claimed in claim 21 or 22, comprising maintaining said tension by use of a cable.

24. A method as claimed in claim 21, 22 or 23, wherein the riser assembly comprises a plurality of flexible steel risers.

25. A method as claimed in claim 24, wherein said risers are maintained in a substantially coplanar arrangement.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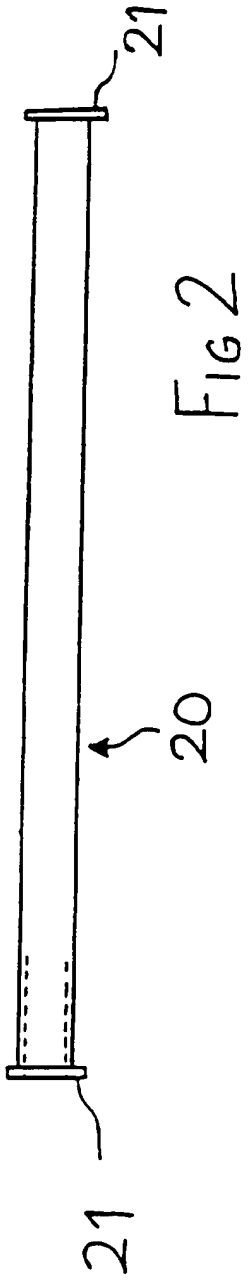

FIG 2

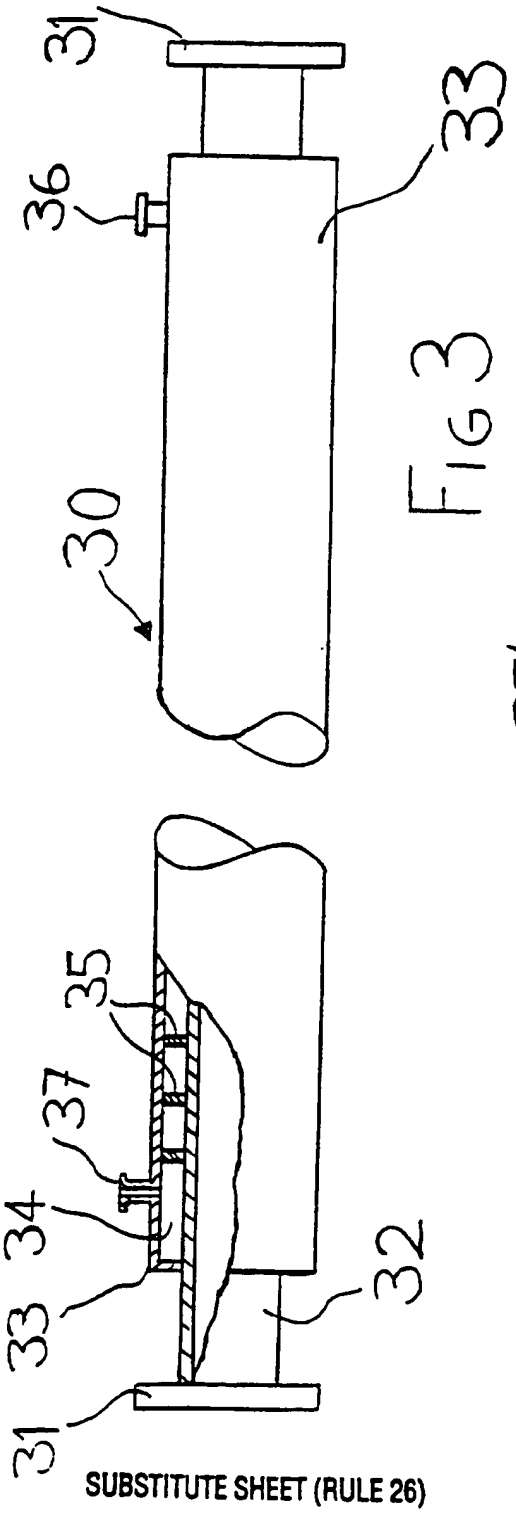

FIG 3

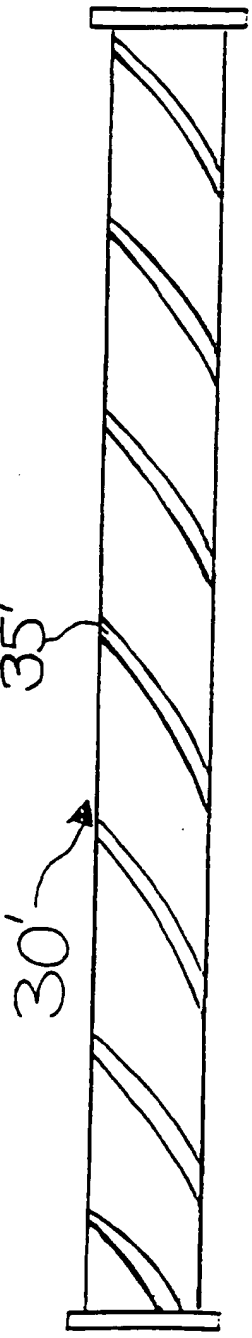

FIG 4

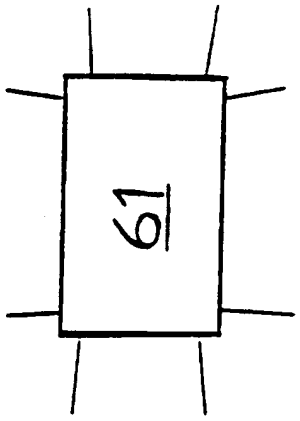

FIG 6

FIG 5

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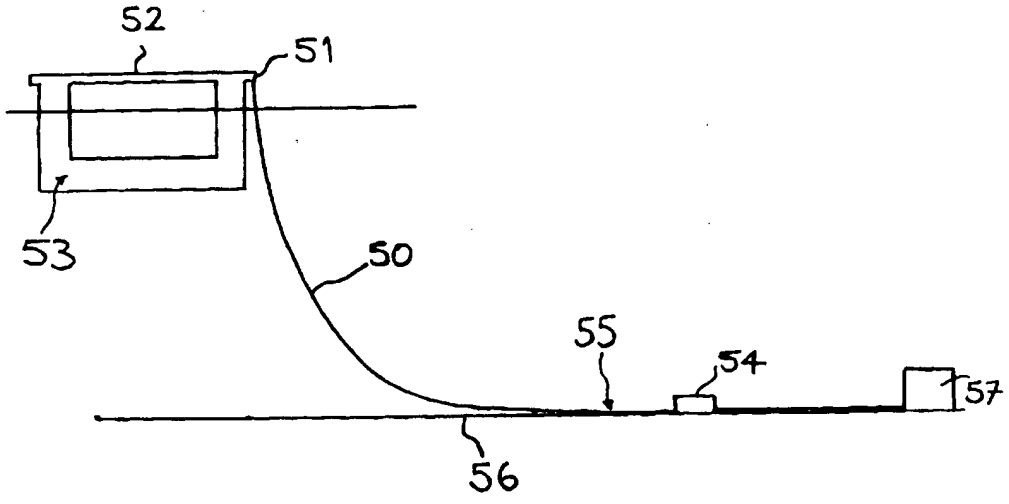

(57) Abstract

Conventional riser assemblies for conveying fluids from undersea oil or gas deposits use flexible hoses. Such hoses are prohibitively expensive for use in deep water locations and are prone to failure. The invention provides an offshore oil or gas production system comprising a floating production vessel (53) and a riser assembly (50) extending between the vessel and a seabed well head (57). The riser assembly comprises at least one flexible steel riser (50) suspended, in catenary, from an outer edge (51) of a deck (52) of the floating production vessel and an anchor (54) located on the seabed (56) and spaced from the well head (57). A riser assembly comprising a plurality of flexible steel risers can be installed quickly by simultaneously laying a plurality of such risers from a reel mounted on a pipe laying vessel and simultaneously disconnected and lowered into a trench on the seabed if it becomes necessary to move the vessel.

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INTERNATIONAL SEARCH REPORT

Int onal Application No
PCT/GB 96/00039

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B17/01 E21B43/017

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	GB,A,2 172 262 (SHELL) 17 September 1986 see the whole document ---	1,6-12, 18 2-5, 13-17, 19,20
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Y	EP,A,0 494 497 (BLANDFORD) 15 July 1992 see column 13, line 49 - column 15, line 17; figures 8C,12 ---	13,14
Y	EP,A,0 251 488 (BECHTEL) 7 January 1988 see --- -/--	15-17,19

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
3 May 1996	19. 08. 96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	FONSECA FERNANDEZ, H

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INTERNATIONAL SEARCH REPORT

Int onal Application No
PCT/GB 96/00039

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	AU,A,32 777 (N.A.ROCKWELL CO.) 1 March 1973 see the whole document ---	1-5,15, 18,20
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A	US,A,3 111 692 (H.D.COX) 26 November 1963 ---	
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INTERNATIONAL SEARCH REPORT

ernational application No.
PCT/GB96/00039

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful internaional search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. Claims 1-20
2. Claims 21-25

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searches without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-20

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

information on patent family members

Int onal Application No
PCT/GB 96/00039

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PCT/GB 96/00039

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